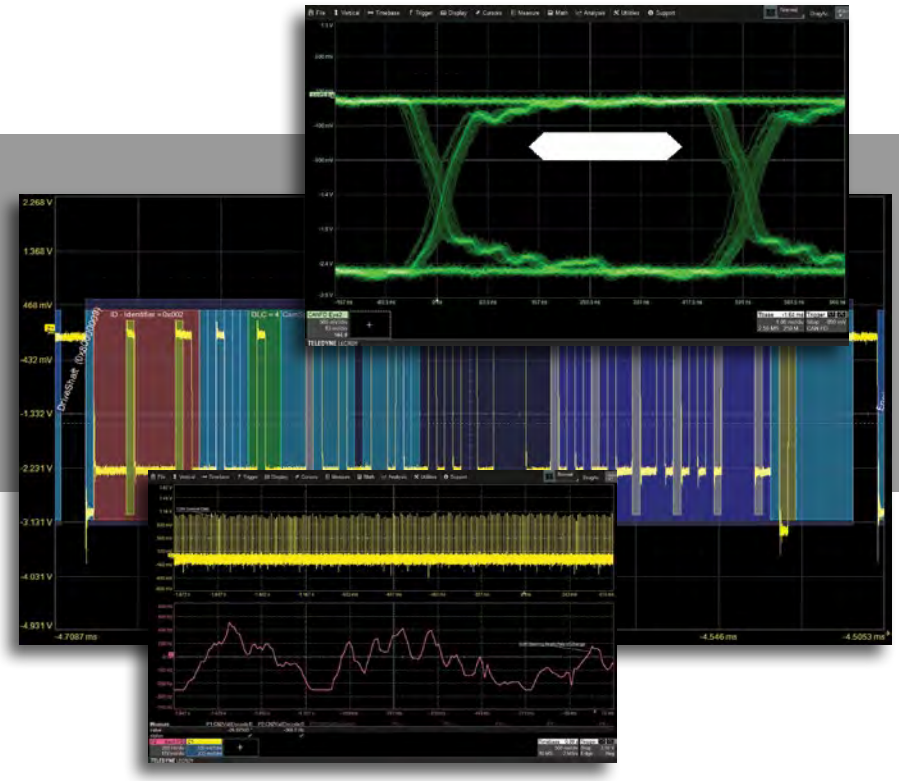
TELEDYNE LECROY
Everywhereyoulook™

Low-speed Serial Data Trigger, Decode, Measure/Graph, and Eye Diagrams



Teledyne LeCroy's Trigger (T), Decode (D), Measure/Graph (M or G) and Eye Diagram and Physical Layer (E or P) options are the best in the industry and nearly universally available across the entire Teledyne LeCroy oscilloscope product line.

Key Features

More than 20 supported standards:

- I^2C
- SPI, SPI DDR, Simplified SPI
- UART and RS-232
- USB 1.x, 2.0 and USB 2.0 HSIC
- 100Base-T1/BroadR-Reach
- CAN, CAN FD, and J1939
- FlexRay
- LIN
- SENT and SENT SPC
- ARINC 429
- MIL-STD-1553
- SPACEWIRE
- 10/100 Base-T Ethernet
- SMBus
- SPMI
- DPHY
- DigRF 3G, DigRF v4
- I^3C
- I^2S, incl. LJ, RJ, TDM
- Manchester and NRZ

Most powerful, flexible triggering capabilities

Intuitive, color-coded decode overlays

Single protocol results table supports up to 4 decoders at one time

Unique measure/graph capabilities:

- Automated timing measurements
- Serial DAC - extract digital data and plot it as a waveform
- Bus parameters

Highest Performance Triggers

Designed by people who know the standards, with the unique capabilities you want to isolate unusual events. Conditional data triggering permits maximum flexibility, and highly adaptable error frame triggering is available to isolate error conditions. Frame definition allows grouping of UART or SPI packets into message frames for customization.

The Best Serial Decoder

Decoded protocol information is color-coded to specific portions of the serial data waveform and transparently overlaid for an intuitive, easy-to-understand visual record. All decoded protocols are displayed in a single time-interleaved table. Touch a row in the interactive table to quickly zoom to a packet of interest and easily search through long records for specific protocol events using the built-in search feature.

Measure/Graph Tools for Validation Efficiency

Quickly validate cause and effect with automated timing measurements to or from an analog signal or another serial message. Make multiple measurements in a single long acquisition to quickly acquire statistics during corner-case testing. Serial (digital) data can be extracted to an analog value and graphed to monitor system performance over time, as if it was probed directly. Complete validation faster and gain better insight.

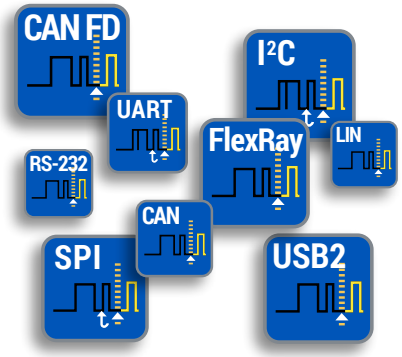
Eye Diagrams & Physical Layer

Rapidly display an eye diagram of your packetized low-speed serial data signal without additional setup time. Use eye parameters to quantify system performance and apply a standard or custom mask to identify anomalies. Mask failures can be indicated and can force the scope into Stop mode.

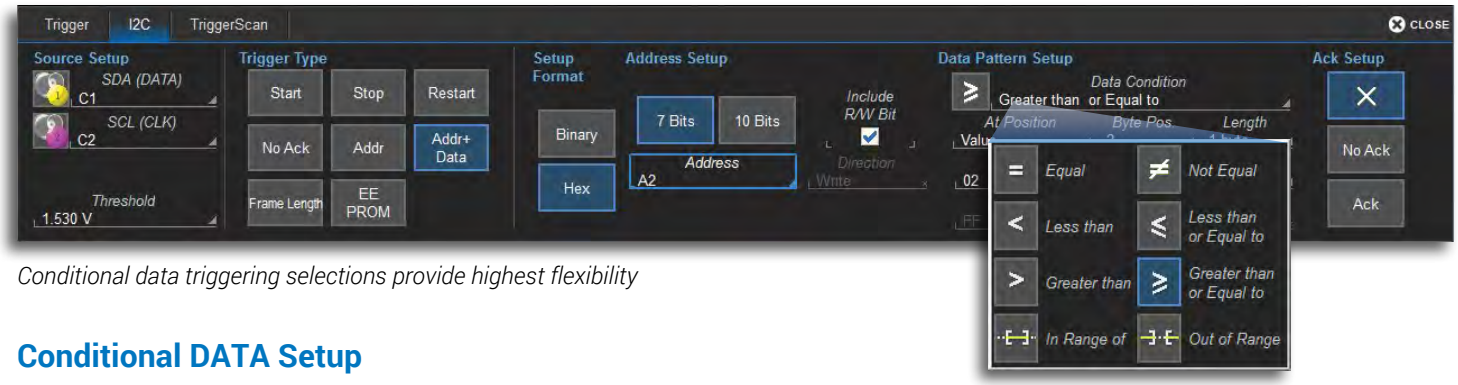
HIGHEST PERFORMANCE TRIGGERS

Every serial trigger we design exhibits deep knowledge of the standard. Most serial triggers work with digital (MSO) inputs, or the EXT input for the Clock line so as to conserve analog channels. Each serial trigger has some unique aspect for high performance, such as:

- **I²C trigger permits triggering on data in a specific location of an up to 2048 byte I²C EEPROM read or write.**
- **UART or SPI bytes can be combined into a single "message frame" - trigger on custom protocols based on UART or SPI byte blocks.**
- **UART supports 9-bit "address" or "wakeup" mode triggering.**
- **CAN, CAN FD, LIN, FlexRay and MIL-STD-1553 permit conditional ID/Address triggering.**
- **CAN and CAN FD permit triggering symbolically using a DBC file.**
- **USB 2.0 and MIL-STD-1553 triggers permits complex transaction definition and triggering.**



High performance and a wide range of support for serial data standards



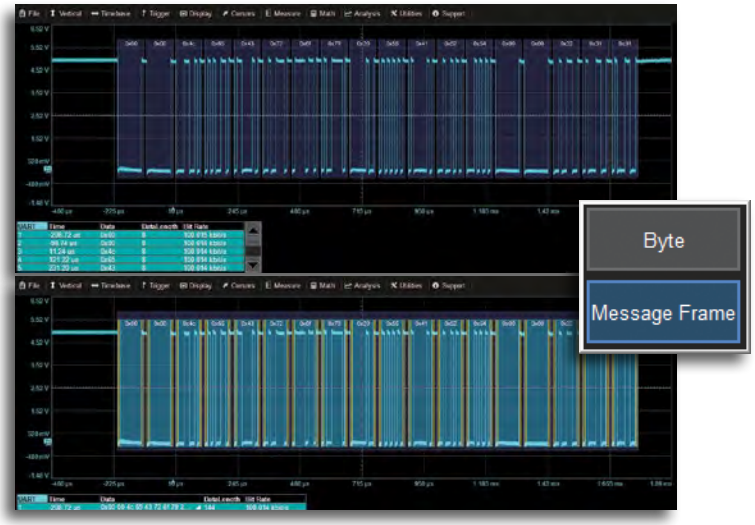
Conditional data triggering selections provide highest flexibility

Conditional DATA Setup

Every Teledyne LeCroy low-speed serial trigger that incorporates DATA trigger permits a conditional (<. <=, =, >, >=, <>, inside a range, outside a range) setup for the DATA condition. This is especially useful in situations where abnormal events should be monitored, such as when a temperature sensor transmitting via I²C exceeds a maximum temperature, or a CAN node broadcasts a low or high engine RPM or coolant pressure. Furthermore, data for triggering can be specifically isolated in very long byte streams to specific bit locations, even those which span data bytes.

Support for Many Proprietary Protocols

Many proprietary serial protocols make use of the common UART (single Data line) or USART (Clock and Data lines, e.g., SPI) byte structures, with multiple bytes grouped into proprietary protocol definitions. Our highly flexible UART byte and SPI format definitions accommodate nearly any customer need, and the UART or SPI bytes can be defined to be part of a single "message frame" through use of our Interframe Setup. Then, the trigger pattern setup can isolate any byte value, e.g., an ID, or a DATA string value, that is part of your proprietary protocol message definition.



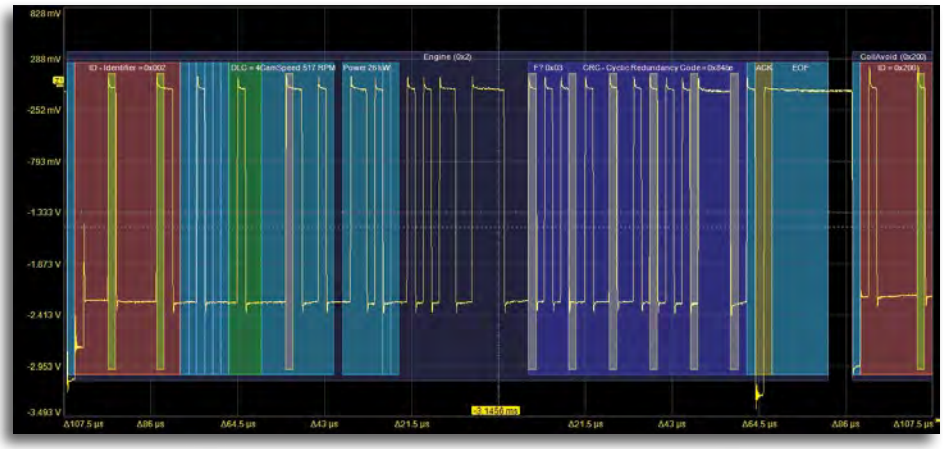
Byte mode (top) treats each byte uniquely. Message Frame mode (bottom) groups bytes into on single, long multi-byte message

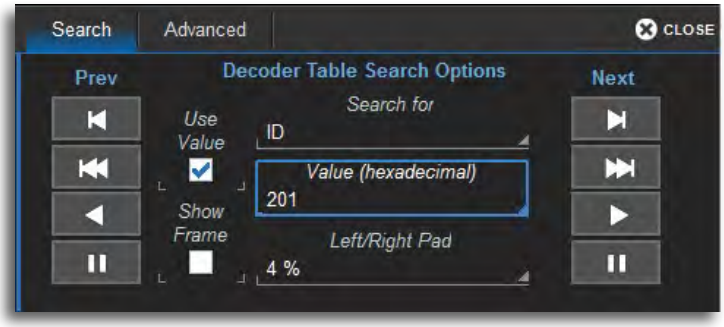
SIMPLY THE BEST SERIAL DECODER

Our serial decode, search and table tools work exactly the way you want. These tools are the industry standard for turning your oscilloscope into a protocol analyzer with fast and intuitive correlation of protocol data to the physical layer waveforms.

Intuitive, Color-Coded Overlays

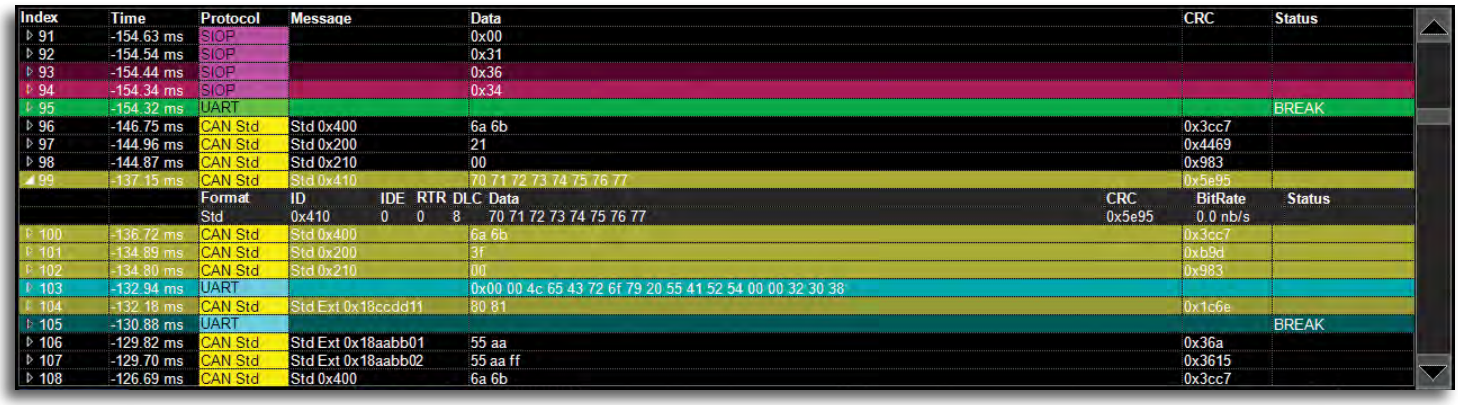
A transparent overlay with color-coding for specific portions of each protocol and the entire message frame makes it easy to understand your serial data information. Unlike other solutions, with protocol decode information away from the signal, our solution correlates the waveform and the protocol decode directly on the display. As the acquisition length is expanded or shortened, the decode overlay will adjust to show you just the right amount of information.





Pattern Search

All decoders provide ability to search through a long record of decoded data by using a variety of search criteria, or values, or simply finding the next occurrence. Pattern Search automatically creates a zoom trace of the acquired waveform and displays the selected location complete with the transparent color-coded overlay.



Index	Time	Protocol	Message	Data	CRC	Status
91	-154.63 ms	SIOP		0x00		
92	-154.54 ms	SIOP		0x31		
93	-154.44 ms	SIOP		0x36		
94	-154.34 ms	SIOP		0x34		
95	-154.32 ms	UART				BREAK
96	-146.75 ms	CAN Std	Std 0x400	6a 6b	0x3cc7	
97	-144.96 ms	CAN Std	Std 0x200	21	0x4469	
98	-144.87 ms	CAN Std	Std 0x210	00	0x983	
99	-137.15 ms	CAN Std	Std 0x410	70 71 72 73 74 75 76 77	0x5e95	
		Format	ID	IDE RTR DLC Data	CRC	BitRate Status
		Std	0x410	0 0 8 70 71 72 73 74 75 76 77	0x5e95	0.0 nb/s
100	-136.72 ms	CAN Std	Std 0x400	6a 6b	0x3cc7	
101	-134.89 ms	CAN Std	Std 0x200	3f	0xb9d	
102	-134.80 ms	CAN Std	Std 0x210	00	0x983	
103	-132.94 ms	UART		0x00 00 4c 65 43 72 6f 79 20 55 41 52 54 00 00 32 30 38		
104	-132.18 ms	CAN Std	Std Ext 0x18ccdd11	80 81	0x1c6e	
105	-130.88 ms	UART				BREAK
106	-129.82 ms	CAN Std	Std Ext 0x18aabb01	55 aa	0x36a	
107	-129.70 ms	CAN Std	Std Ext 0x18aabb02	55 aa ff	0x3615	
108	-126.69 ms	CAN Std	Std 0x400	6a 6b	0x3cc7	

Interactive Table Summarizes Results

Turn the oscilloscope into a protocol analyzer with a tabular display of decoded information. Customize the table to show only the data of interest and touch a message in the table to automatically zoom to it and display it on the screen. Export the table for offline analysis. Up to four different decoded signals of any type may be simultaneously displayed in the table.

MEASUREMENT / GRAPHING - EXTEND YOUR KNOWLEDGE

Key Features

Timing measurements

- Serial Message to Analog Signal
- Analog Signal to Serial Message
- Serial Message to Serial Message

Serial DAC measurement/graphing

Bus status measurements

Automated – quickly gather statistics, display Histograms

Quickly correlate cause-effect timing relationships to other events

Conditional filtering

Supported for

- I^2C
- SPI, SPI DDR, Simplified SPI, Custom SPI
- UART and RS-232
- USB 1.x and 2.0
- CAN, CAN FD
- LIN
- FlexRay
- SENT and SENT SPC
- ARINC 429
- MIL-STD-1553
- I^3C
- SMBus
- SPMI
- DigRF 3G, DigRF v4
- I^2S, incl. LJ, RJ, TDM (note: Serial DAC graph, or "G" capability only)

The measurement and graphing capabilities significantly enhance our trigger and decode packages, and help you debug and validate faster.

Digital data can be extracted and rescaled to an analog value and graphed over time, time-correlated to other acquired data, as if you had probed it directly. It's a Serial Data DAC!

Automated cause-effect timing measurements can be made between analog signals and serial data messages, or two serial data messages. Use with serial triggering and long acquisitions to understand system behavior during stress or corner-case testing. A variety of bus status measurements are also available.

All measurements may be used with the rich set of standard Teledyne LeCroy standard parameter analysis tools, including automated pass/fail analysis with boolean test conditions, measurement gates, measurement accept, filtering, parameter math, and custom math.

Setup is easy in the Measure/Graph setup tab:

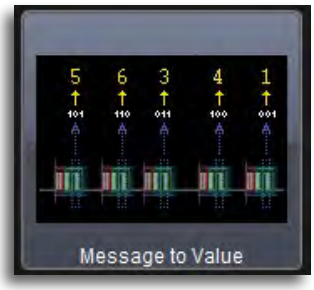
1. Choose the source
2. Choose the measurement
3. Select the destination parameter (e.g., P2)
4. Then apply and configure

Serial Data DAC and Graphing Tools

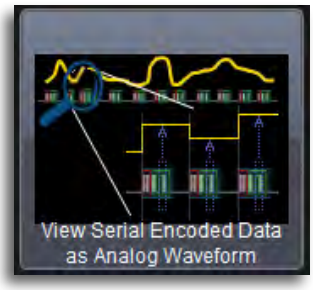
Digital data can be extracted from specific locations in the serial data message using the Message to Value measurement parameter - a serial data DAC. This information can then be displayed as a measurement parameter value(s), or it can be viewed as a time-correlated waveform displaying the measurement value over time - as if you were able to probe and acquire it directly. Use the long acquisition time of the oscilloscope to understand how the data changes over long periods of time, in conjunction with other system behaviors.

Some examples of the usefulness of this capability are:

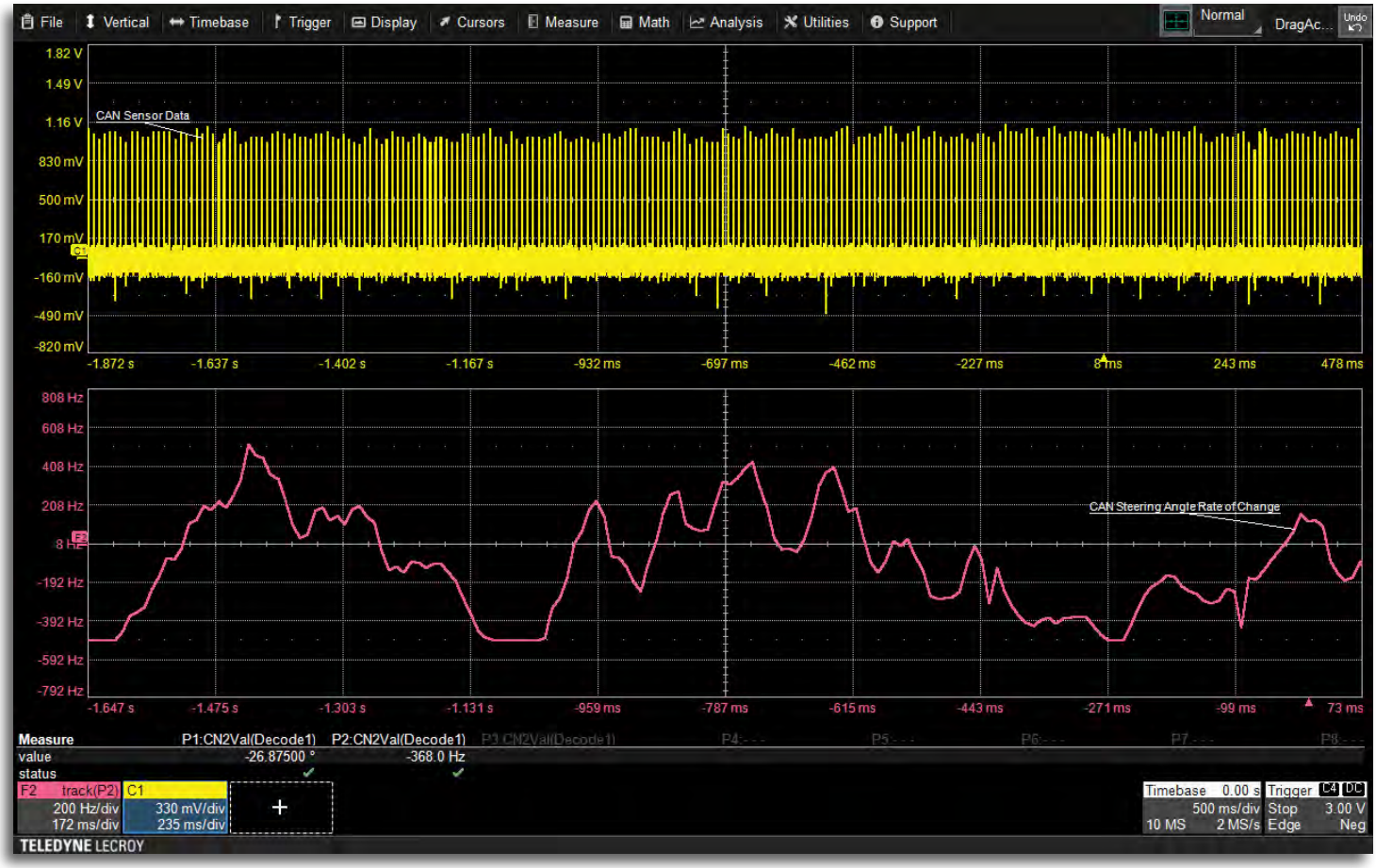
- Viewing I²C or SPI temperature sensor data
- Viewing DigRF 3G radio frequency I and Q modulated signals
- Viewing CAN wheel speed information used by an ABS
- Viewing reconstructed analog audio from serial I²S streams



Decoded data content of data payload of a protocol message meeting conditions.



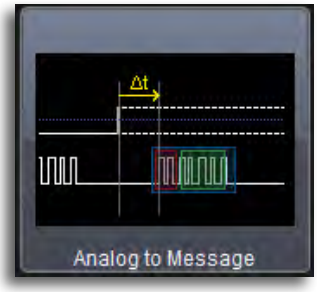
Applies a Track math operator to the Message to Value measurement to view Serial Encoded Data as an Analog Waveform



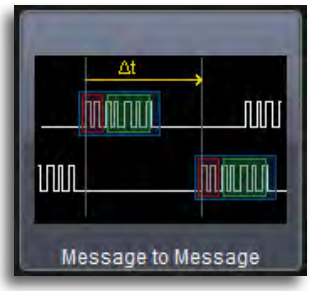
Shown above is a long acquisition of a CAN serial data signal (top waveform) that contains embedded digital data for steering wheel angle rate of change (deg/s, or Hz). The Message to Value parameter was configured to locate and extract the digital steering wheel angle range data from particular locations in specific CAN serial messages, and then converted from digital to analog form with proper re-scaling and physical units. The serial data DAC waveform (bottom waveform) is shown in the lower grid.

Automated Timing Measurements

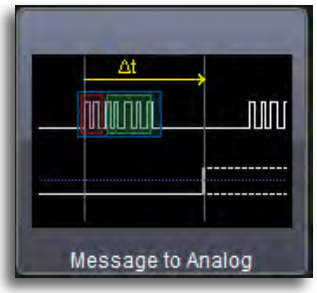
Utilize a serial trigger to isolate a specific message and then measure a cause-effect timing relationship with a subsequent analog signal, or vice versa. But instead of manually measuring the timing with cursors, use these tools to automate the measurement and return thousands of values quickly as your system undergoes stress testing. Automate the measurement and validation of gateway latency times from one serial message to another (e.g. CAN to LIN or low-speed CAN to high-speed CAN, or CAN to FlexRay) without having to manually use cursors or compare values and times in a protocol table. Quickly understand bus latency times or arbitration behaviors by measuring the difference between two messages on a single decoded waveform. Dramatically improve your validation efficiency and time to insight



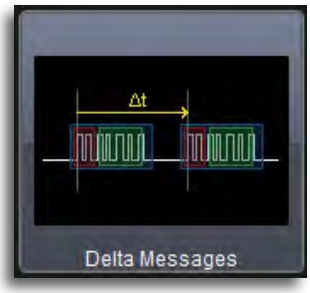
Analog to Message
Computes the time difference from a protocol message meeting specified conditions to the crossing of a threshold on an analog signal.



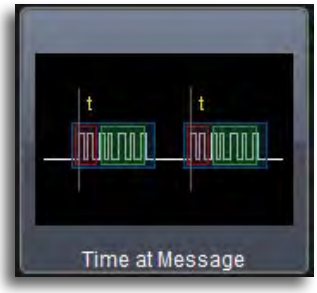
Message to Message
Computes the time difference from a protocol message meeting specified conditions to another protocol message meeting specified conditions



Message to Analog
Computes the time difference from a protocol message meeting specified conditions to the crossing of a threshold on an analog signal.



DeltaMessage Time
Computes the time difference between two messages on a single decoded line.

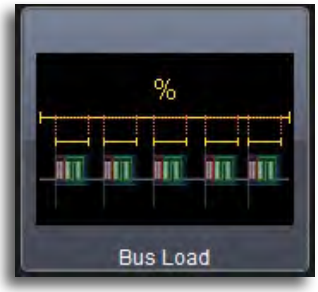


Time@Message
Time from Trigger to each protocol message meeting specified conditions.

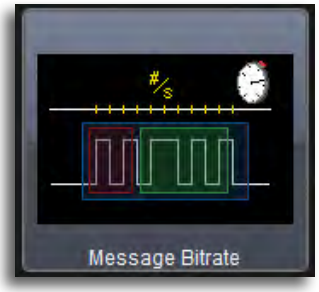
Use the Message to Analog measurement to find the time between an I²C data packet and a control signal on another channel. Multiple measurements in one or more triggers could be made to understand behaviors over time or under different operation conditions

Bus Status Measurements

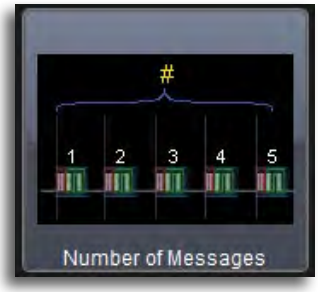
The bus status measurements Bus Load, Message Bitrate, and Number of Messages, give an overall status of the decode protocol to quickly learn if the bus is over utilized and to verify the bit rate matches expectations.



Message Bus Load %
Computes the load of user defined message in percent on the bus



Message Bit Rate
Computes the bitrate of the user specified messages on the decoded trace.



Number of Messages
Computes the number of message matching user definition in a decoded trace.

The Perfect Oscilloscopes for the TDME Options

Teledyne LeCroy HDO, WavePro HD, and WaveRunner oscilloscopes are the perfect oscilloscope platforms to utilize the TD and TDME toolsets.

Teledyne LeCroy's 12-bit High Definition Oscilloscopes (HDOs), such as WaveRunner 8000HD, WavePro HD, HDO6000A, and WaveSurfer 4000HD provide 12-bit resolution and either 4 or 8 analog input channels up to 8 GHz with MSO digital input options. These oscilloscopes have powerful standard toolsets for debugging deeply embedded designs with analog, digital, serial data, and sensor signals. Their 12-bit resolution is ideal for measuring sensor signals and correlating them to other system activities. 8 analog input channels provides more ability to correlate more signals to each other.

Teledyne LeCroy 8-bit Oscilloscopes, such as the WaveRunner 9000 Series, are also extensively used for embedded system debug. Their standard toolsets complement the TDME packages extremely well.

EYE DIAGRAM AND PHYSICAL LAYER

Eye Diagrams are "bit-sliced" views of the physical layer serial data waveforms. They provide a fast, intuitive way to understand physical layer signal integrity. Eye Diagrams may be combined with masks and mask failure indications, and eye (opening) parameters. Protocols with challenging topologies (e.g. FlexRay) provide even more advanced measurement capabilities.

Key Features

Up to four simultaneous Eye Diagrams

Simple to set up - one button push

Include standard or custom masks. Create your own masks.

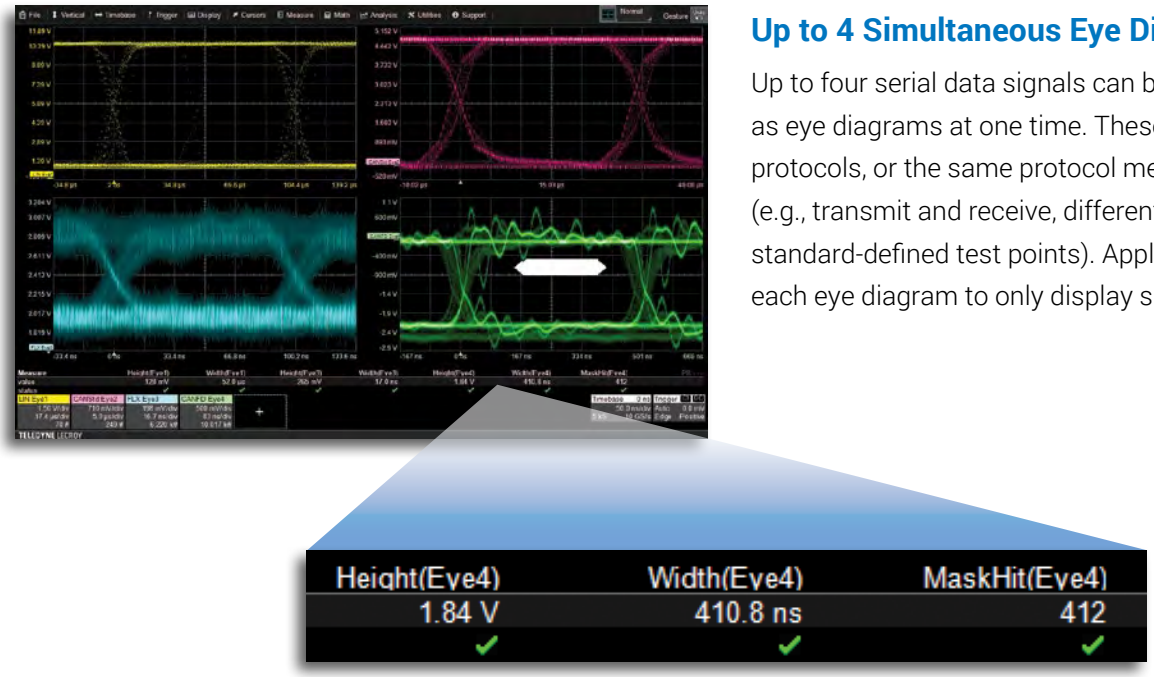
Eye parameters

Mask failure indication

Failure locator trace waveform

Pass/Fail with STOP on failure

Eye diagrams "slice" each bit and overlay them to get a consolidated view of signal quality. Intrusions into the eye opening or onto a mask indicate potential problems.



Up to 4 Simultaneous Eye Diagrams

Up to four serial data signals can be decoded and displayed as eye diagrams at one time. These can be different protocols, or the same protocol measured at different points (e.g., transmit and receive, different nodes, or different standard-defined test points). Apply a user-defined filter to each eye diagram to only display specific signals in the eye.

Eye Diagram Measurement Parameters

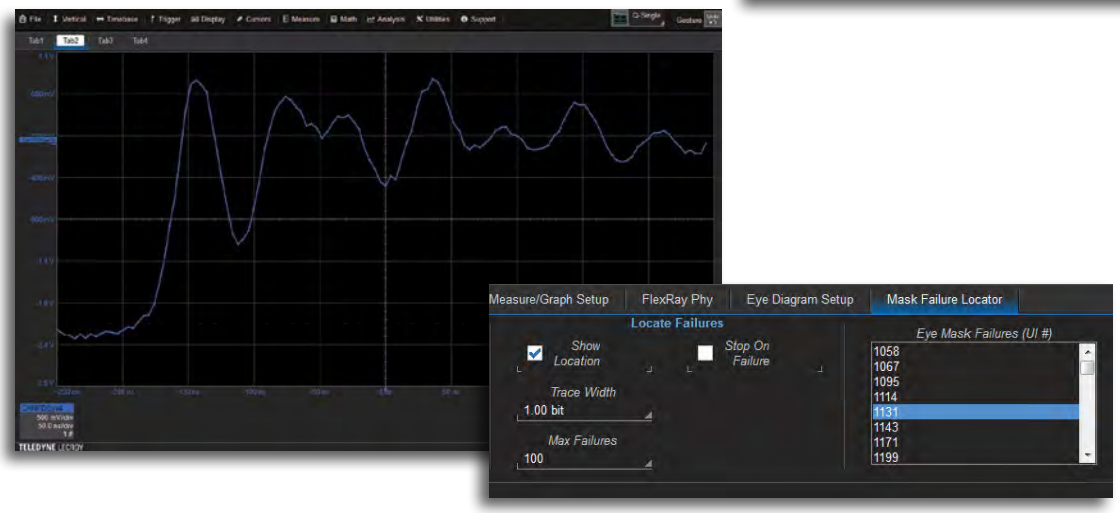
Quantify physical layer signal quality in the eye by applying parameters for Eye Height, Eye Width, and Number of Mask Failures. Some packages (e.g. FlexRay TDMP) go a step further and include additional measurements defined in the standard.

MASK AND MASK FAILURE INDICATION

E

Mask and Mask Failure Indication

A user-defined or pre-defined mask may be added to the eye diagram so as to objectively evaluate if the physical layer signal intrudes too far into the eye opening. Apply a filter to include or exclude specific messages from the Eye so as to determine failure source (e.g., messages from a specific node or with a specific ID). Mask failures are indicated with a red circle and can be displayed in a table. Touch the failure table to open a zoom of the failed area for further inspection



PHYSICAL LAYER (EYE + ADVANCED MEASUREMENTS)

P

Some standards, due to their speed or nodal complexity, provide specific guidance on what eye diagrams or measurements should be made and exactly how they should be performed. FlexRay, and MIPI DPHY are examples. In these cases, the Eye Diagram ("E") capability is augmented with additional specialized "P" capability (for Physical Layer Measurements), per the standard. In these cases, the "E" capabilities previously described are also available.

Key Features

Symbolic trigger setup, decode, and data extraction and graph setup using (customer-supplied) DBC file

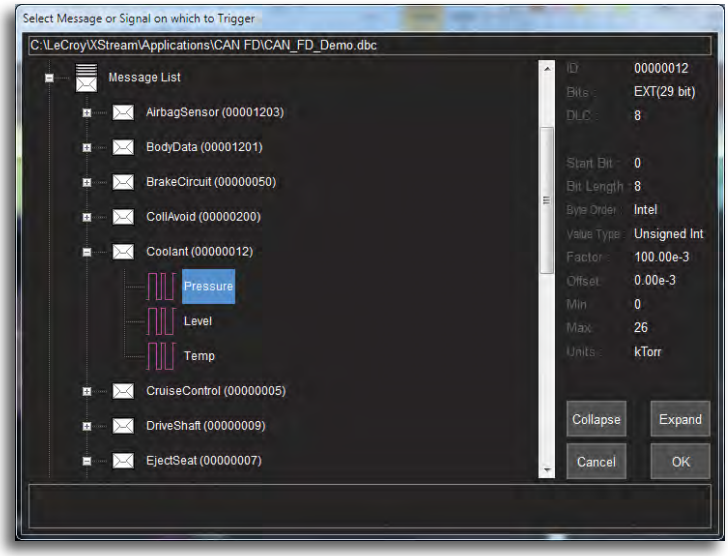
Error-frame red color decode highlight

DATA trigger pattern setup can be less than full bytes/nibbles and can be spread across bytes

Conditional ID definition (<, <=, =, >, >=, <>, IN RANGE, OUT of RANGE)

Supports 29-bit GM CAN Priority ID, Source ID, Parameter ID trigger and decode

Supports J1939 decode

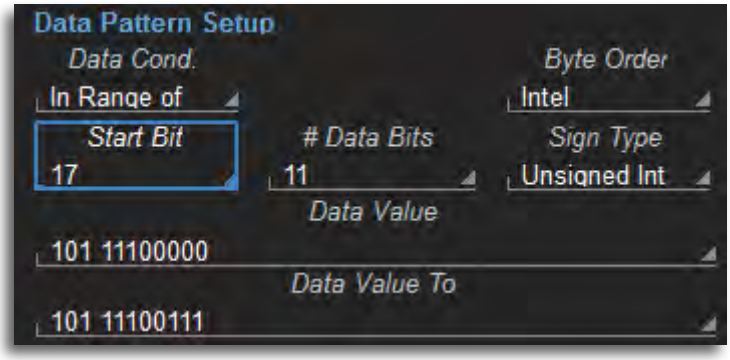


Symbolic (DBC) File Support

CAN and CAN FD Symbolic decode options both support use of a customer-supplied DBC file for signal selection for triggering and CAN to Value serial data DAC setup. Additionally, the decode annotation is in Symbolic format as well, with complete message and signal structures described.

Trigger Flexibly Across Data Bytes

CAN remains the most used vehicle serial data bus. Many vehicle bus software architectures are very message dense, and data for a single message is spread across multiple data bytes. The hexadecimal and measurement toolsets permit isolation of specific bit-level data patterns in one or more data bytes, e.g., data location in bits 17-28 in data bytes 3, 4, and 5. This provides significant advantages in isolating the exact information or behavior you need. Symbolic message/signal setup is even simpler.



SPECIFICATIONS

	CANbus TD, CAN FDbus TD, CANbus TDME, CAN FDbus TDME	CANbus TDME Symbolic, CAN FDbus TDME Symbolic
Definition		
Protocol Setup	CANbus and CAN FDbus: Select Source. Select BitRate and Data BitRate. CAN FDbus Only: Select Frame Type (EDL) Both (X), CAN Standard (0), or CAN FD (1). For CAN FD, select ISO FRAME, and BR Select (BRS) Both(X), Normal(0), or FD(1).	
Trigger Capability		
Format	Hexadecimal or Binary. ID and DATA can be set up with different formats.	ID: Symbolic, Hexadecimal, Binary. DATA: Symbolic, Hexadecimal or Binary. ID and DATA can be set up with different formats.
Trigger Setup	Trigger on ID, ID+DATA, REMOTE, ERROR, or ALL (Data, Remote, or Error Frame) frames. Set Requested (Bit) Sampling Point from 20 to 90% (Basic) or set values for Prop Seg, Phase_Seg1, Phase_Seg2, and SJW for (Advanced).	
ID Setup	**Hexadecimal or Binary:** Specify STD (11-bit) or EXT (29-bit) ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Supports triggering when both 11-bit and 29-bit IDs are present on the bus.	**Symbolic**: Specify a Message to trigger on using customer supplied DBC database file. Choose from list sorted by Node, Message, or Signal. GM CAN compatible (Priority ID, Parameter ID, Source ID). **Hexadecimal or Binary:** Specify STD (11-bit) or EXT (29-bit) ID(s) with condition of <=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE. Supports triggering when both 11-bit and 29-bit IDs are present on the bus.
DATA Setup	**Hexadecimal:** # Data Bytes = 0 to 8 (CAN) or 0-12. (CAN FD) Data bytes can be defined by nibble. **Binary:** Any combination of 0,1, or X for 1-64 (CAN) or 0-96 (CAN FD) bits Data pattern can be any length and can be set to start at any location in the up to 8 (CAN) or 12 (CAN FD) Byte / 64 (CAN) or 96 (CAN FD) bit sequence. Byte Order Intel or Motorola format, Signed or Unsigned Data.	**Symbolic:** Message+Signal with Signal value set in scaled units as defined in customer supplied DBC database file. **Hexadecimal:** # Data Bytes = 0 to 8 (CAN) or 0-12. (CAN FD) Data bytes can be defined by nibble. **Binary:** Any combination of 0,1, or X for 1-64 (CAN) or 0-96 (CAN FD) bits Data pattern can be any length and can be set to start at any location in the up to 8 (CAN) or 12 (CAN FD) Byte / 64 (CAN) or 96 (CAN FD) bit sequence. Byte Order Intel or Motorola format, Signed or Unsigned Data.
DATA Cond. Setup	<=, <, =, >, >=, <>, IN RANGE, OUT OF RANGE, or DON'T CARE	
Error Frame Setup	Select any combination of All Error Frames, Stuff Bit Errors, CRC Mismatch Errors. In CAN FDbus, also select Stuffbit Counter Error and Stuffbit Counter Parity Error.	
Remote Frame Setup	Supported for ID. Capability identical to ID Condition Setup.	
Bit Rates	Nominal Bit Rate: 10, 25, 33.333, 50, 83.333, 100, 125, 250, 500 kb/s, or 1 Mb/s pre-defined nominal values, or user-defined from 10 kb/s to 1 Mb/s. CAN FD Data Bit Rate: 0.5, 1.0, 1.5, 2.0, 5.0, 8.0, or 10 Mb/s pre-defined nominal values, or user-defined to any nominal value from 0.5 to 10 Mb/s.	
Trigger Input	Any analog Channel or Digital input, or the EXT input.	
Decode + Search Capability		
Format	Hexadecimal	Symbolic (Message and Signal level) or Hexadecimal. Symbolic decode requires user-provided DBC database file.
Decode Setup	Threshold definition required. Default is to Percent amplitude. Select bit rate(s).	
Decode Input	Any analog Channel, Memory or Math trace, and any Digital trace.	
# of Decode Wfms	Up to 4 buses may be decoded at one time. In addition, zooms can be displayed (with decoded information).	
Visual Aid	Color Coding for FRAME, ID, IDE, EDL, BRS, ESI, RTR, DLC, DATA, CRC, ACK, STUFF BITS, BIT INDEX, and ERRORS. Error Frames are decoded whenever possible, with uncorrupted portions decoded to Identify Type. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.	Color Coding for FRAME, ID, IDE, EDL, BRS, ESI, RTR, DLC, DATA, CRC, ACK, STUFF BITS, BIT INDEX and ERRORs. Symbolic includes textual Message name and physical Signal value with units. Error Frames are decoded whenever possible, with uncorrupted portions decoded to Identify Type. Decode information is intelligently annotated based on timebase setting, and overlaid on acquired waveform.
Table Configure, Export Table	Display 1 to 20 rows of decoded information for up to 4 different protocols or decodes in time order in a single table. Displayed information includes Index, Timestamp, and other various protocol-specific information. Table permits scrolling, touch to zoom, export to .csv file, and special display of long data or other patterns.	
Pattern Search	Search for Previous or Next Index, ID, IDE, DLC, DATA, and STATUS	

CANbus TDME, CANbus TDME Symbolic, CAN FDbus TDME, CAN FDbus TDME Symbolic only	
Measure / Graph Capability	
Serial Data Digital-to-Analog Conversion (DAC)	**Message to Value** measurement parameter extracts and converts a specified portion of the data in an up to 2048 byte data/payload in the serial message and displays it as an analog decimal value. Supports different data encoding formats, message filtering to specific IDs, and complete re-scaling with unit conversion. **Serial DAC Waveform** plots the converted digital-to-analog data as a waveform time-correlated to other acquisition data, and view the change in data over time.
Timing Measurements	**Message to Analog, Analog to Message, Message to Message, ΔMessage Time** (identical message on same decoder), **Time@Message** (time from trigger). Serial Message may be defined by "ID =" (where applicable) and user-defined DATA with condition <=, <, =, >, >=, <>, IN RANGE, or OUT OF RANGE in any location in up to 2048 bits of data. Analog Signal may be defined by Slope (pos, neg), Level (abs or %) with Hysteresis setting. Holdoff may be set on the Analog Signal by either Time or Events (up to 1000) to preclude unwanted measurements.
Bus Status Measurements	**Number of Messages, Message Bit Rate, Message Bus Load %**. Serial Message may be defined by "ID =" (where applicable) and user-defined "DATA <=, <, =, >, >=, <>, in range, out of range" in any location in up to 2048 bits of data.
Eye Diagram Capability	
Setup	Create up to four simultaneous Eye Diagrams (one per Serial Decoder) of the physical layer signal(s). Eye Style selectable as color- or analog-persisted. Eye Saturation adjustable from 0 to 100%.
Eye Parameters	Eye Height, Eye Width, (Number of) Mask Hits
Eye Mask	Create a custom Mask using the free Teledyne LeCroy MaskMaker software utility. Store custom masks for later recall and use.
Failure Indication and Location	Mask Failure Indication ON or OFF (ON = indicated with a red circle). Mask Failure Location trace waveform displayed and interactive with Eye Mask failure table. Supports STOP trigger on Mask Failure.